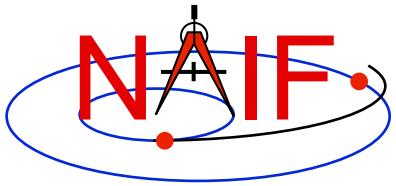


Navigation and Ancillary Information Facility

WebGeocalc

A Tutorial

http://wgc.jpl.nasa.gov:8080/webgeocalc

January 2014

Rev. 1

Overview

Navigation and Ancillary Information Facility

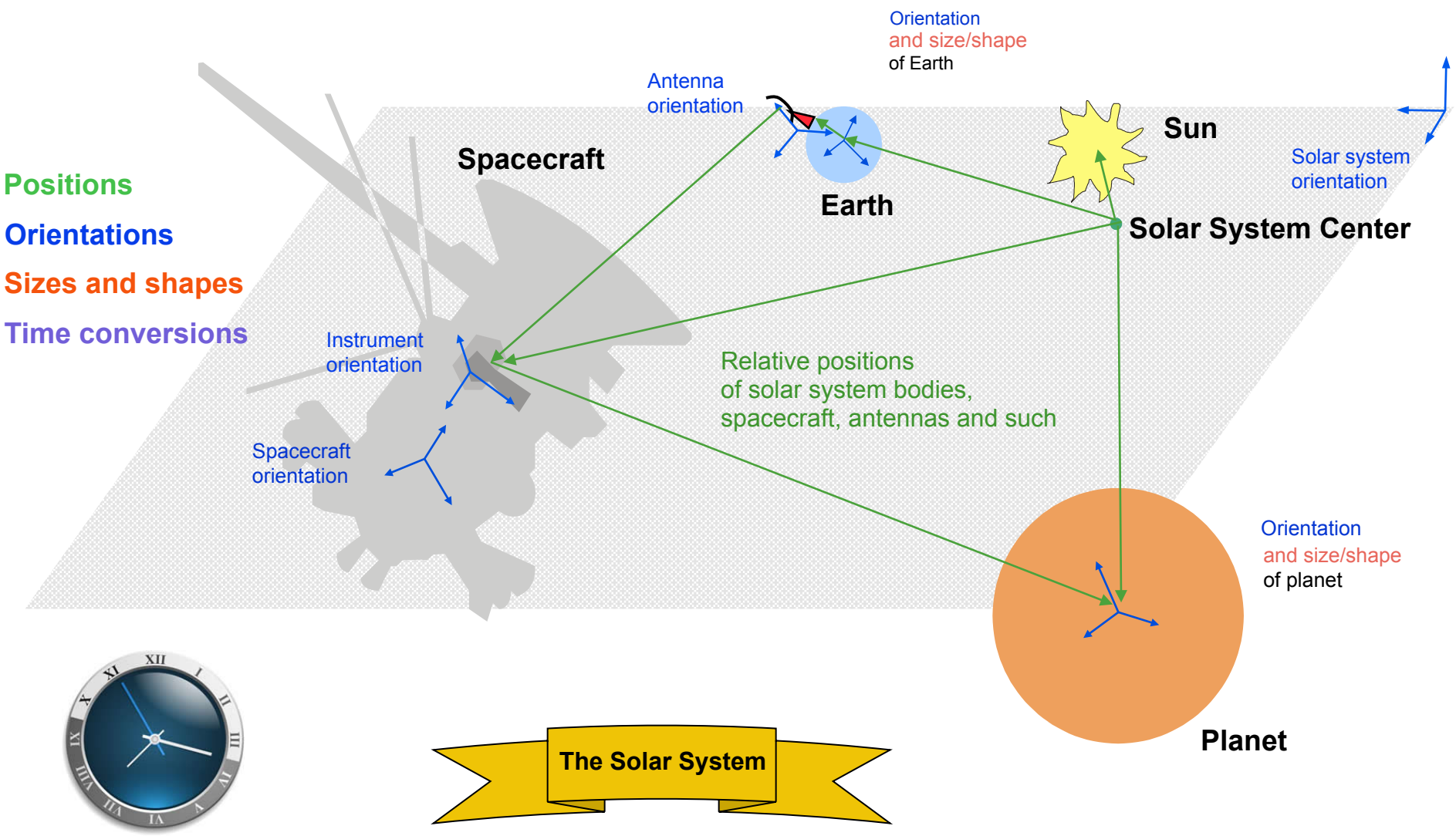
- **WebGeocalc (WGC) is useful in making space geometry computations using SPICE ancillary data**
  - **See the next page for a graphic depicting "ancillary data"**
  - **SPICE description:**

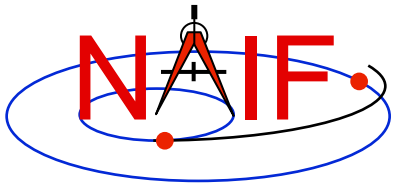
    http://naif.jpl.nasa.gov/naif/aboutspice.html

- **WGC provides a Graphical User Interface (GUI) to a SPICE server running a geometry computation engine**
  - **Using WGC is easier than having to write your own program that incorporates some SPICE Toolkit software**
  - **But WGC provides only a subset of the computational capability available from SPICE Toolkit software**

What are Ancillary Data?

Navigation and Ancillary Information Facility





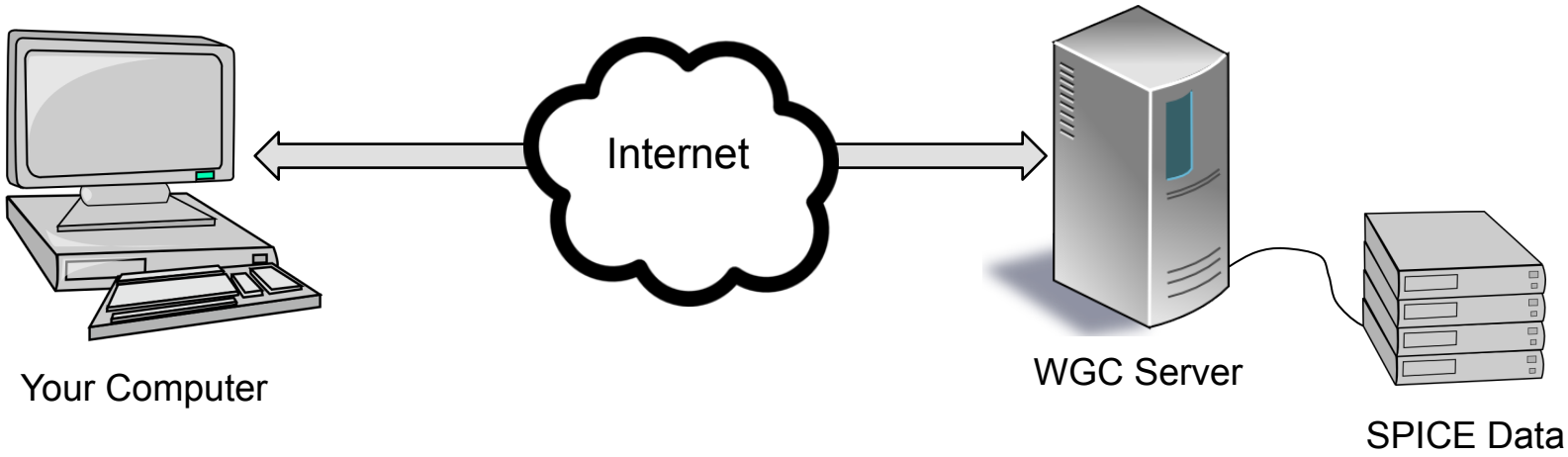
Purpose

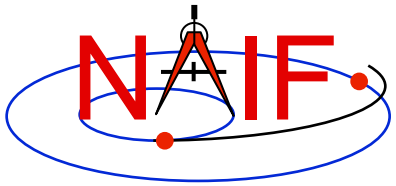
- **WGC can support planetary science in several ways**
  - **Help a user check his/her own SPICE-based program under development**
  - **Help a user quickly solve a one-time space geometry problem**
  - **Allow those unable to write a SPICE-based program to nevertheless make space geometry computations**
  - **Help a peer reviewer do spot checks of geometry parameters contained in an archive about to be submitted to an archive center**

Architecture

Navigation and Ancillary Information Facility

- **WGC uses a client-server architecture**
  - **The user need have only a computer running a web browser**
  - **The browser connects via Internet to a WGC "computation engine" running on a web server**
    - » **The WGC server has access to a set of SPICE kernels (data)**





Using WebGeocalc

- **WGC makes it "easy" to do many kinds of SPICE computations**
  - **You need not write a program using SPICE Toolkit software**
  - **Instead, open a web browser and use standard GUI widgets to:**
    - » **read a variety of HELP statements**
    - » **select the computation desired**
    - » **select the data to be used in your computation**
    - » **specify the computation details**
    - » **press the "CALCULATE" button**
  - **Your results, possibly including some plots, appear in your browser window**
- **There are a number of conditions under which WGC will not be able to fulfill your request**
  - **See the Limitations and Errors pages at the end of this tutorial for some examples**

Computations

Navigation and Ancillary Information Facility

- **Three categories of SPICE computations are possible**
  1. **Geometry Calculator**
     - » **Compute a parameter value at a given time, or over a time range**
       - **Example: Compute the angular size of Phobos as seem from the SPIRIT Mars rover from 2009 March 10 12:00:00 to 2009 March 10 14:00:00**
  2. **Geometric Event Finder**
     - » **Within a specified time bounds (the confinement window)…**
       - **Find time intervals when a particular geometric condition exists**
         - **Example: Find time intervals when Phobos is occulted by Mars as seen from Mars Odyssey within the period 2010 June 01 to 2010 June 02**
       - **Find time intervals when a parameter is within a given range**
         - **Example: Find time intervals when the spacecraft altitude is between 300 and 400 km**
       - **Find time intervals when a parameter has reached a local or global maximum or minimum**
         - **Example: Find time intervals when the angular separation of a satellite from a planet, as seen from a spacecraft, has reached its minimum value**
  3. **Time conversion calculator**
     - » **Convert between various time systems and time formats**
- **See the WGC "menu" on the next page for some details**

Computation Menu*

Navigation and Ancillary Information Facility

Geometry Calculator

State Vector	Position and velocity of target relative to observer.
Angular Separation	Angle between 2 targets as seen from an observer.
Angular Size	Apparent size of a target as seen from an observer, as an angle.
Frame Transformation	Transformation between 2 reference frames.
Illumination Angles	Sunlight incidence, emission, and phase angles at a point on a target body as seen from an observer.
Sub-solar Point	Sub-solar point on a target body as seen from an observer.
Sub-observer Point	Closest point on a target body to an observer.
Surface Intercept Point	Coordinates of the intercept point of a ray in a reference frame, as seen from an observer.
Orbital Elements	Orbital parameters of a target body relative to a central observing body.

Geometric Event Finder

Position Finder	Find time intervals when target coordinate satisfies a condition.
Angular Separation Finder	Find time intervals when the angle between 2 bodies, as seen by an observer, satisfies a condition.
Distance Finder	Find time intervals when the distance between a target and observer satisfies a condition.
Sub-Point Finder	Find time intervals when the sub-observer point on a target satisfies a condition.
Occultation Finder	Find time intervals when a target is occulted by, or is in transit across, another body.
Surface Intercept Finder	Find time intervals when the surface intercept of a ray in a reference frame satifies a coordinate condition.
Target in Field of View	Find time intervals when a target is within the field of view of an instrument.
Ray in Field of View	Find time intervals when a specified ray is within the field of view of an instrument.

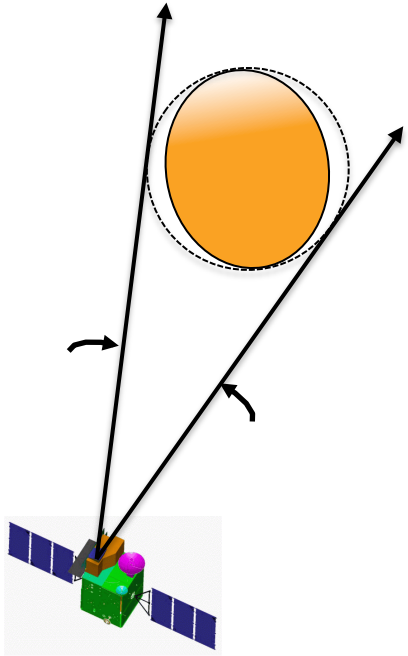
Time Calculator

Time Conversion	Convert time values from one time system to another.

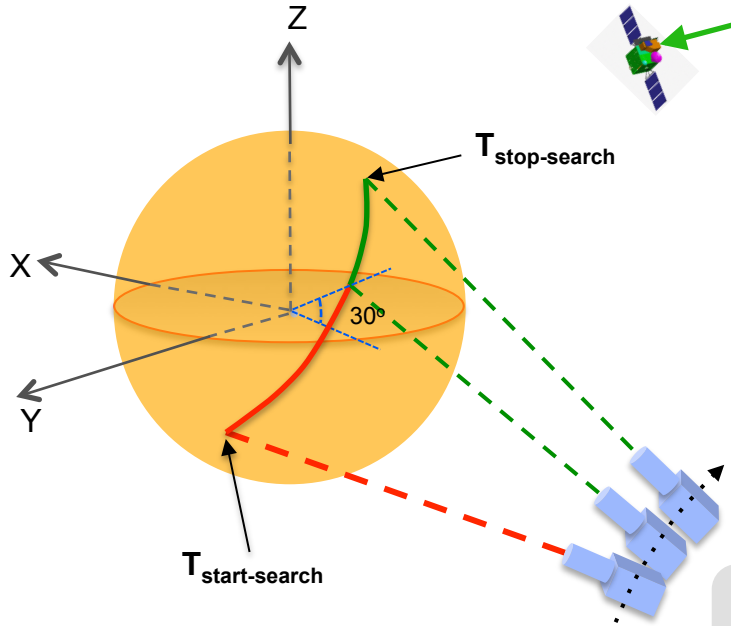
* Current as of October 2013; more computations may be added if resources permit

Illustrations of Three Available Computations

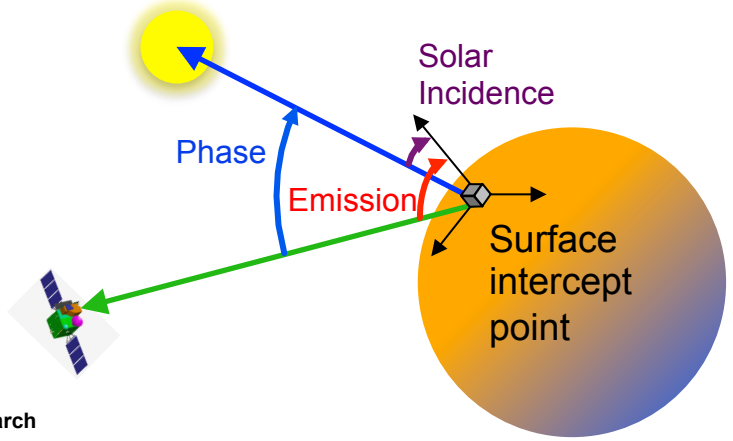
Navigation and Ancillary Information Facility



Angular Size



Camera scanning across the planet's surface



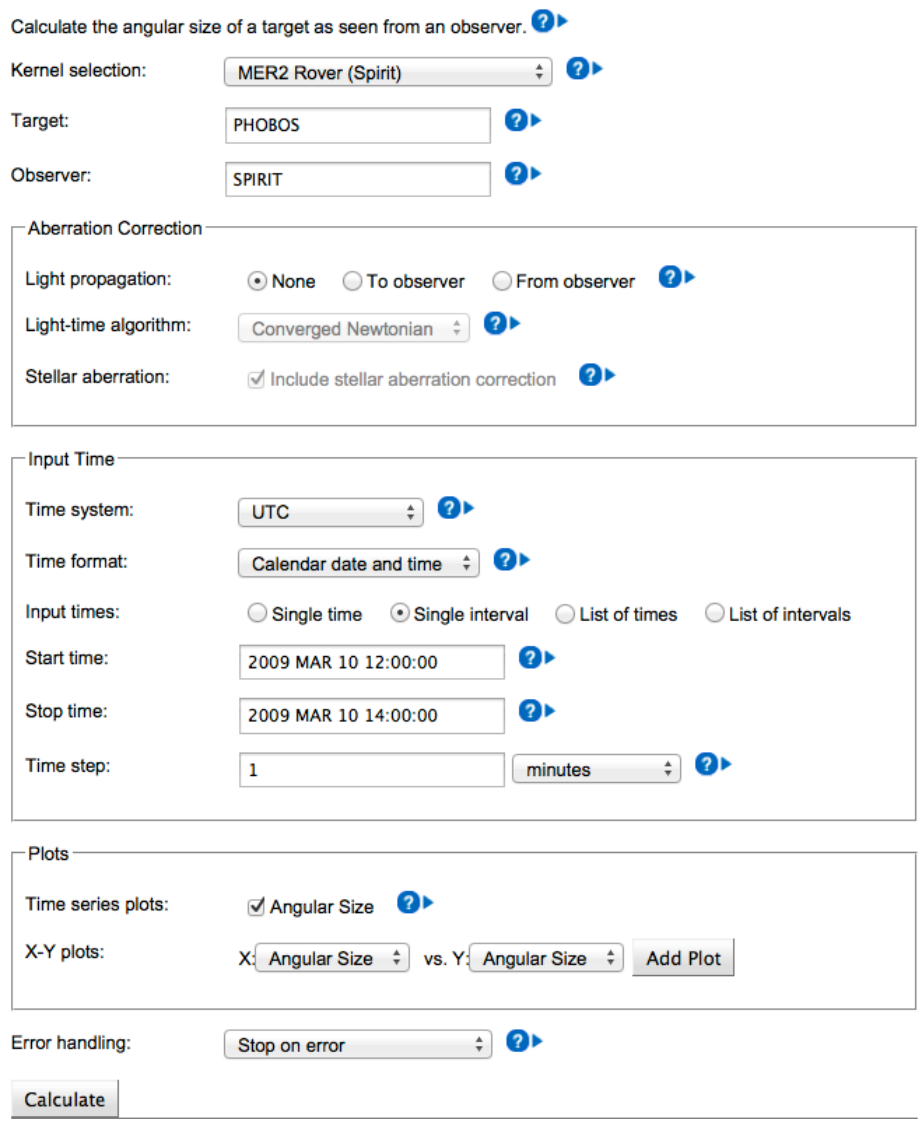
Illumination Angles

The **GREEN** trace shows when the latitude of the instrument boresight surface intercept is greater than 30 degrees, within the time range $T_{start\text{-}search}$ to $T_{stop\text{-}search}$.

Surface Intercept Event Finder

Typical Geometry Calculator Input

Navigation and Ancillary Information Facility



- **Compute the angular size of Phobos as seen from the Mars rover "SPIRIT" over a two hour period on 2009 March 10**
- **Use typical GUI drop-down menus, fill-in boxes, radio buttons and check boxes to specify the details of the computation you wish to make**

Typical Geometry Calculator Output

Navigation and Ancillary Information Facility

Input Values

Calculation type	Angular Size
Target	PHOBOS
Observer	SPIRIT
Light propagation	No correction
Time system	UTC
Time format	Calendar date and time
Time range	2009 MAR 10 12:00:00 to 2009 MAR 10 14:00:00, step 1 minutes

Summary of your input

Angular size of Phobos as seen from the Mars rover "SPIRIT"

Tabular Results

Click a value to save it for a subsequent calculation.

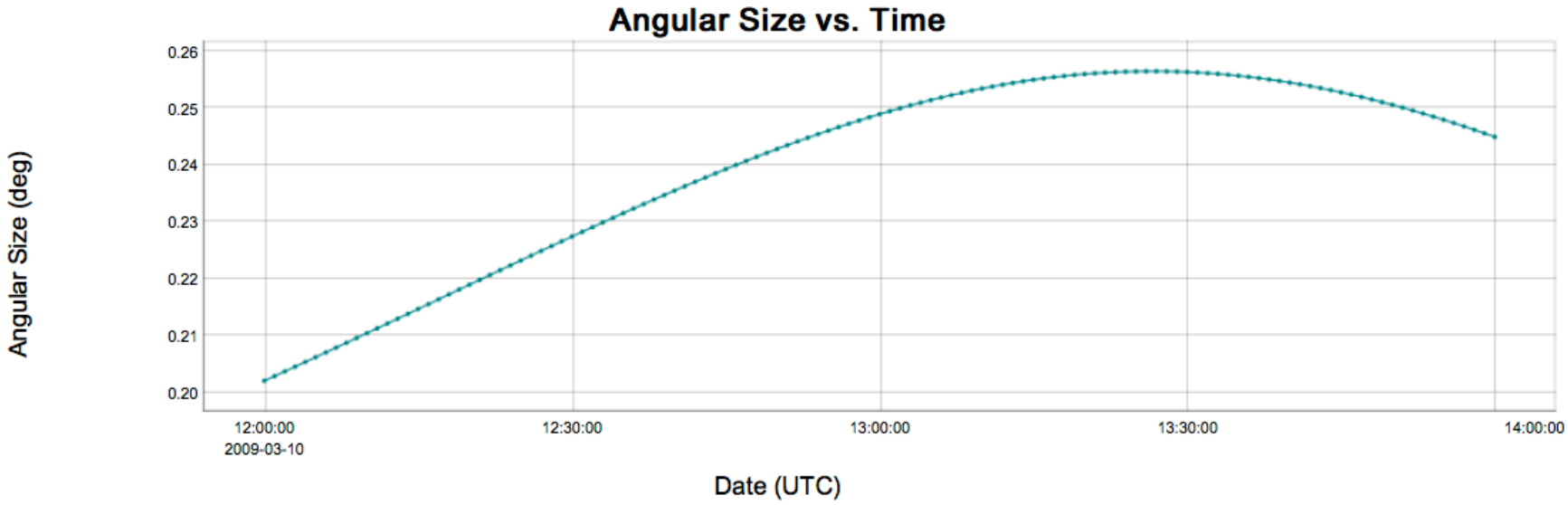
	UTC calendar date	Angular Size (deg)
1	2009-03-10 12:00:00.000000 UTC	0.20212256
2	2009-03-10 12:01:00.000000 UTC	0.20294481
3	2009-03-10 12:02:00.000000 UTC	0.20377024
4	2009-03-10 12:03:00.000000 UTC	0.20459871
5	2009-03-10 12:04:00.000000 UTC	0.20543007
6	2009-03-10 12:05:00.000000 UTC	0.20626418
7	2009-03-10 12:06:00.000000 UTC	0.20710088
8	2009-03-10 12:07:00.000000 UTC	0.20794000
9	2009-03-10 12:08:00.000000 UTC	0.20878138
10	2009-03-10 12:09:00.000000 UTC	0.20962484
11	2009-03-10 12:10:00.000000 UTC	0.21047019
12	2009-03-10 12:11:00.000000 UTC	0.21131725
13	2009-03-10 12:12:00.000000 UTC	0.21216581
14	2009-03-10 12:13:00.000000 UTC	0.21301567

Tabular results

Typical Geometry Calculator Plot

Navigation and Ancillary Information Facility

- **Some Geometry Calculator computations offer optional plots**

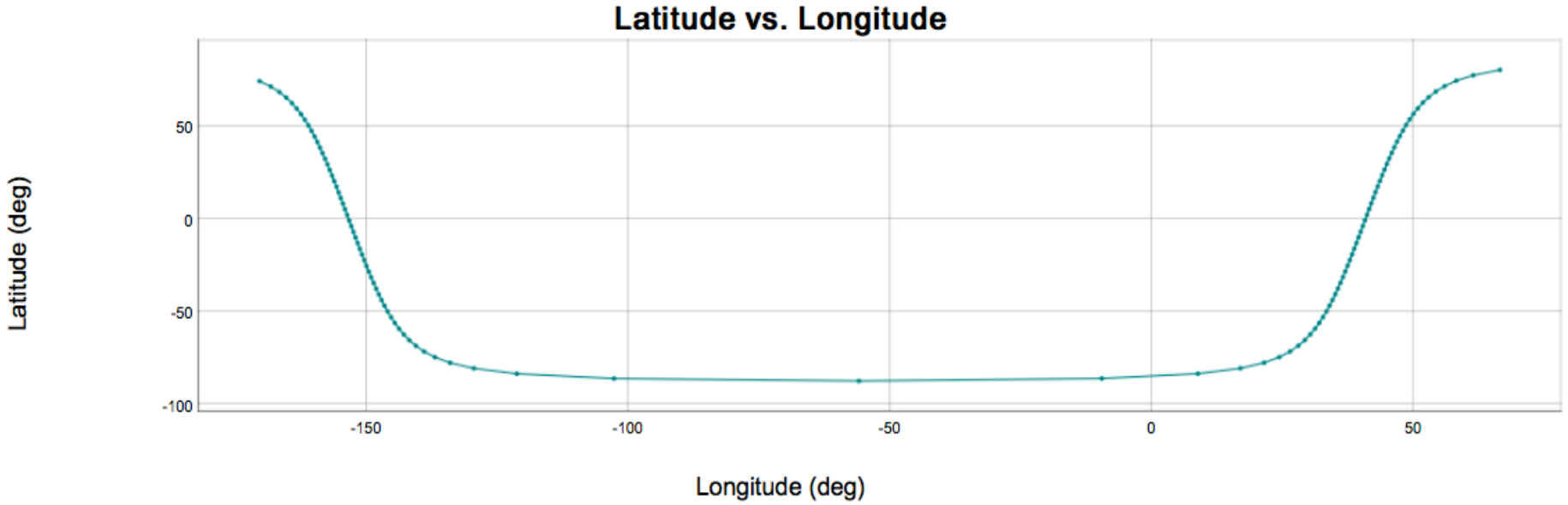


Angular size of Phobos as seen from the Mars rover "SPIRIT"

Another Geometry Calculator Plot

Navigation and Ancillary Information Facility

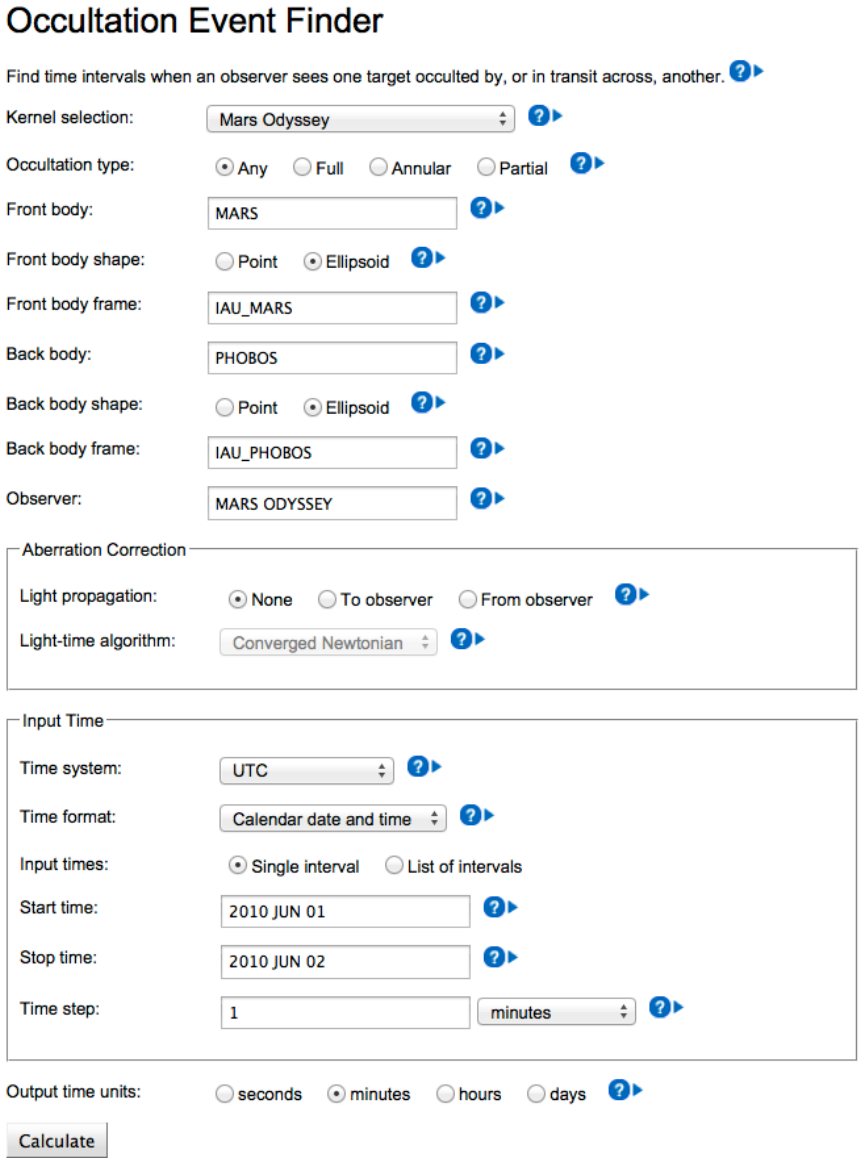
- **Some Geometry Calculator computations offer plots using other than time on the X axis**



Mars Global Surveyor sub-point on Mars
from 2008 JAN 1 00:10:00 to 2008 JAN 1 02:00:00

Typical Geometric Event Finder Input

Navigation and Ancillary Information Facility



- **Find the times when Phobos is occulted by Mars as viewed from the Mars Odyssey spacecraft, during the period 2010 JUN 01 to 2010 JUN 02**

- **Use typical GUI drop-down menus, fill-in boxes, radio buttons and check boxes to specify the details of the computation you wish to make**

Typical Geometric Event Finder Output

Navigation and Ancillary Information Facility

Input Values

Calculation type	Occultation Event Finder
Occultation type	Any
Front body	MARS
Front body shape	Ellipsoid
Front body frame	IAU_MARS
Back body	PHOBOS
Back body shape	Ellipsoid
Back body frame	IAU_PHOBOS
Observer	MARS ODYSSEY
Light propagation	No correction
Time system	UTC
Time format	Calendar date and time
Time range	2010 JUN 01 to 2010 JUN 02, step 1 minutes
Output time units	minutes

Summary of your input

When is Phobos occulted by Mars as seen from Mars Odyssey?

Tabular Results

Click a value to save it for a subsequent calculation.

Save All Intervals

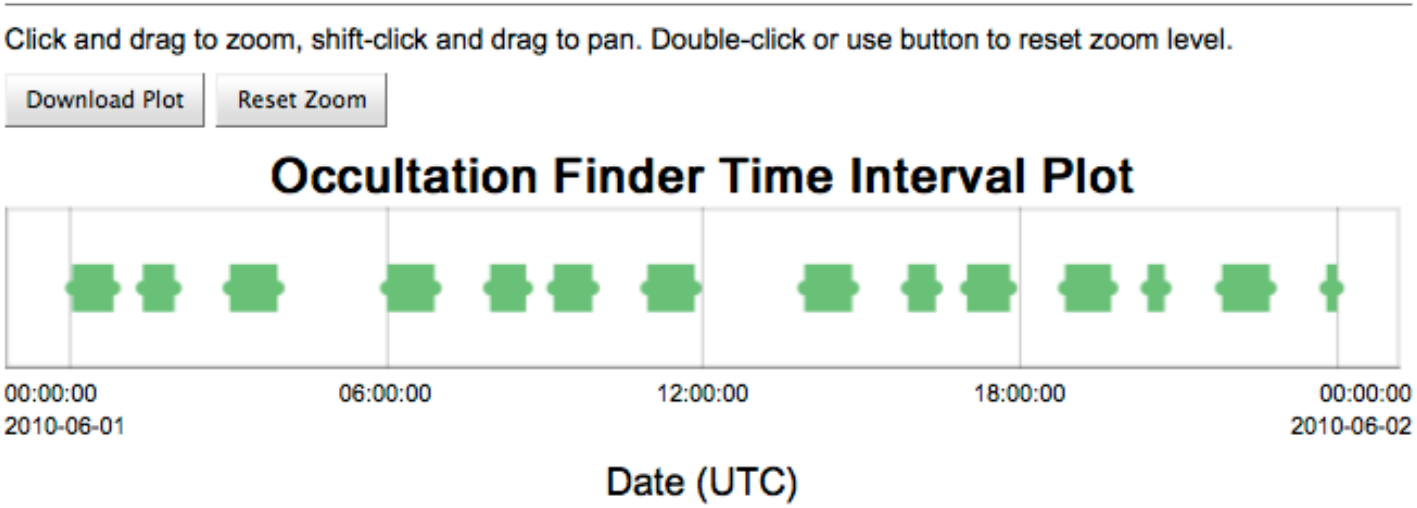
	Start Time	Stop Time	Duration (mins)
1	2010-06-01 00:04:26.021732 UTC	2010-06-01 00:51:10.264641 UTC	46.737381
2	2010-06-01 01:24:29.613301 UTC	2010-06-01 02:00:24.470706 UTC	35.914290
3	2010-06-01 03:03:10.407364 UTC	2010-06-01 03:57:18.126849 UTC	54.128658
4	2010-06-01 06:01:49.736199 UTC	2010-06-01 06:55:34.722424 UTC	53.749770
5	2010-06-01 07:58:43.095947 UTC	2010-06-01 08:39:21.182114 UTC	40.634769
6	2010-06-01 09:10:48.846727 UTC	2010-06-01 09:54:44.492005 UTC	43.927421
7	2010-06-01 10:57:18.630420 UTC	2010-06-01 11:50:49.343214 UTC	53.511879
8	2010-06-01 13:55:36.186600 UTC	2010-06-01 14:49:37.827064 UTC	54.027341
9	2010-06-01 15:53:04.642891 UTC	2010-06-01 16:24:27.068718 UTC	31.373763
10	2010-06-01 17:00:06.149085 UTC	2010-06-01 17:48:55.474342 UTC	48.822087
11	2010-06-01 18:51:22.462322 UTC	2010-06-01 19:43:35.637833 UTC	52.219591
12	2010-06-01 20:25:04.806659 UTC	2010-06-01 20:44:18.076413 UTC	19.221162
13	2010-06-01 21:49:30.099608 UTC	2010-06-01 22:43:34.010176 UTC	54.065176

Tabular results

Typical Geometric Event Finder Plot

Navigation and Ancillary Information Facility

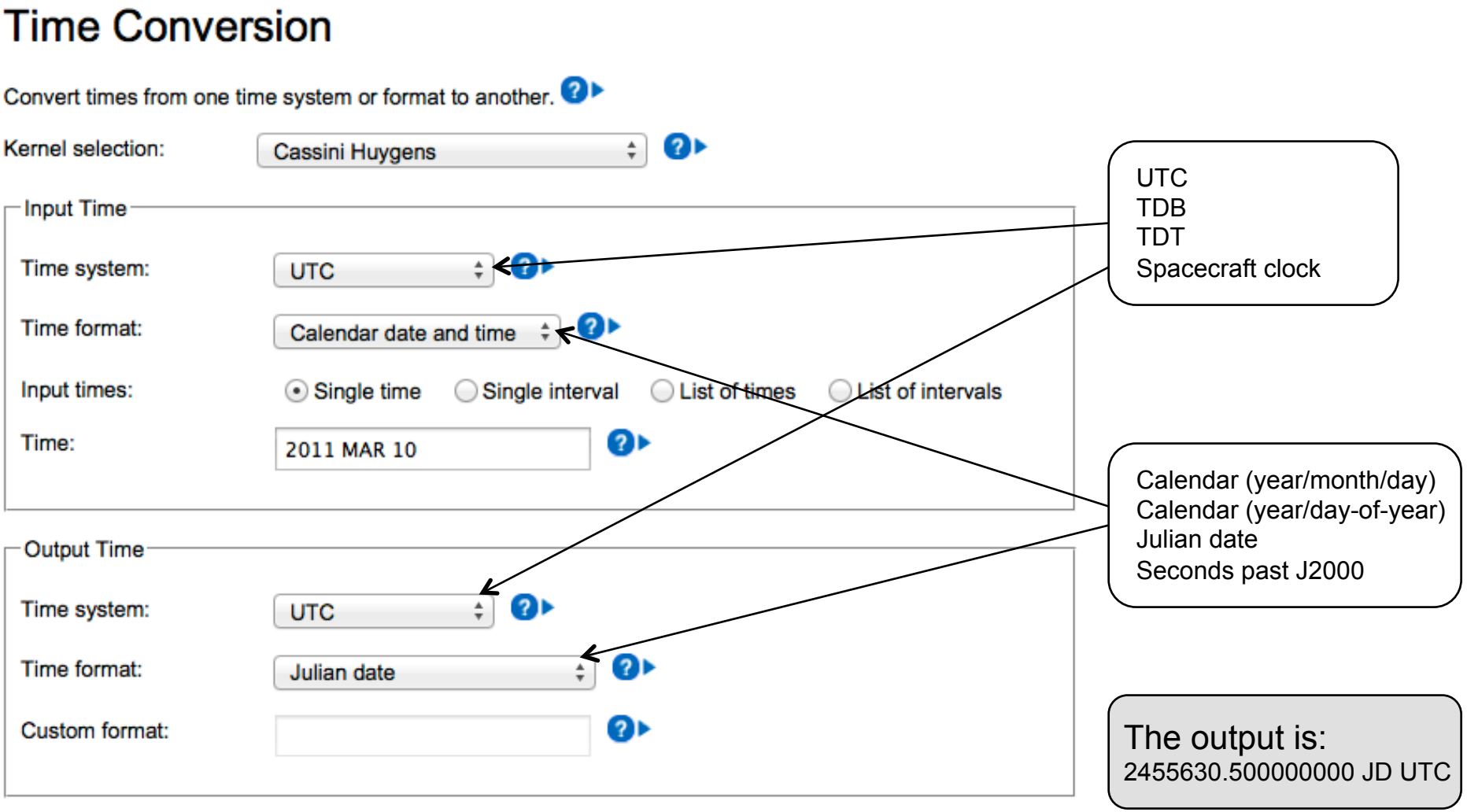
- **Geometric Event Finder computations all produce "plots" of the time intervals that satisfy your search computations**



Between June 1, 2010 and June 2, 2010, find times when Phobos is occulted by Mars, as viewed from the Mars Odyssey spacecraft

First Example of Time Conversion

Navigation and Ancillary Information Facility



Second Example of Time Conversion

Navigation and Ancillary Information Facility

Time Conversion

Convert times from one time system or format to another.

Kernel selection: Mars Reconnaissance Orbiter

Input Time

Time system: UTC

Time format: Calendar date and time

Input times: Single time | Single interval | List of times | List of intervals

Start time: 2011 MAR 10

Stop time: 2011 MAR 11

Time step: 20 minutes

Output Time

Time system: UTC

Time format: Julian date

Custom format:

UTC
TDB
TDT
Spacecraft clock

Calendar (year/month/day)
Calendar (year/day-of-year)
Julian date
Seconds past J2000

The output is:

2011-03-10 00:00:00.000000 UTC 2455630.500000000 JD UTC
2011-03-10 00:20:00.000000 UTC 2455630.513888900 JD UTC
2011-03-10 00:40:00.000000 UTC 2455630.527777800 JD UTC
2011-03-10 01:00:00.000000 UTC 2455630.541666700 JD UTC
etc. etc.

Third Example of Time Conversion

Navigation and Ancillary Information Facility

Time Conversion

Convert times from one time system or format to another.

Kernel selection: Lunar Reconnaissance Orbiter

Input Time

Time system: Spacecraft clock Spacecraft clock ID: -85

Time format: Spacecraft clock string

Input times: (•) Single time ( ) Single interval ( ) List of times ( ) List of intervals

Time: 1/0330220800.000

Output Time

Time system: UTC

Time format: Calendar (year-month-day)

Custom format:

Spacecraft clock string
Spacecraft clock ticks

Calendar (year/month/day)
Calendar (year/day-of-year)
Julian date
Seconds past J2000
Custom format

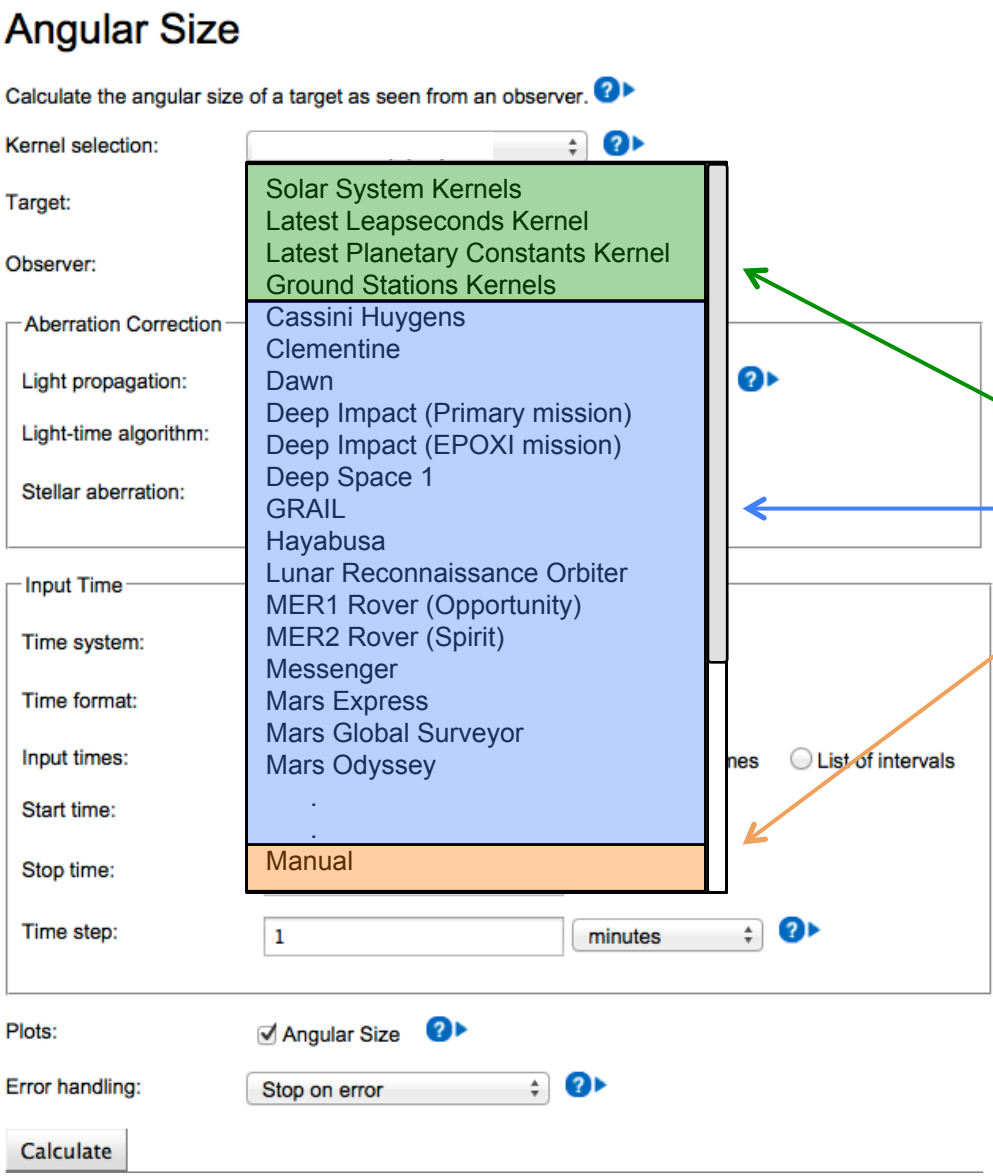
The output is:
2011-06-20 00:00:00.044032 UTC

Categories of Available Data

- As of January 2014 only the JPL/NAIF Group is operating a WGC server
  - This server provides access to three categories of SPICE data
    - » Generic SPICE data, not specifically tied to a single planetary mission
    - » Archived SPICE data from planetary missions that have been formally ingested into NASA's Planetary Data System
      - This includes a few non-NASA missions
    - » Operations SPICE data for JPL-operated planetary missions, for three ESA planetary missions, and for a few past missions for which an archive does not exist
      - This category often includes some predictive data
      - This category is the most difficult to use because…
        - there are no meta-kernels for these collections
        - there is sometimes a large number of kernels from which you must choose the ones needed
        - there is little readily available information to help you make your kernel choices
  - VERY IMPORTANT: Read the "About the data" text provided within the tool for details

Kernel Selection

Navigation and Ancillary Information Facility



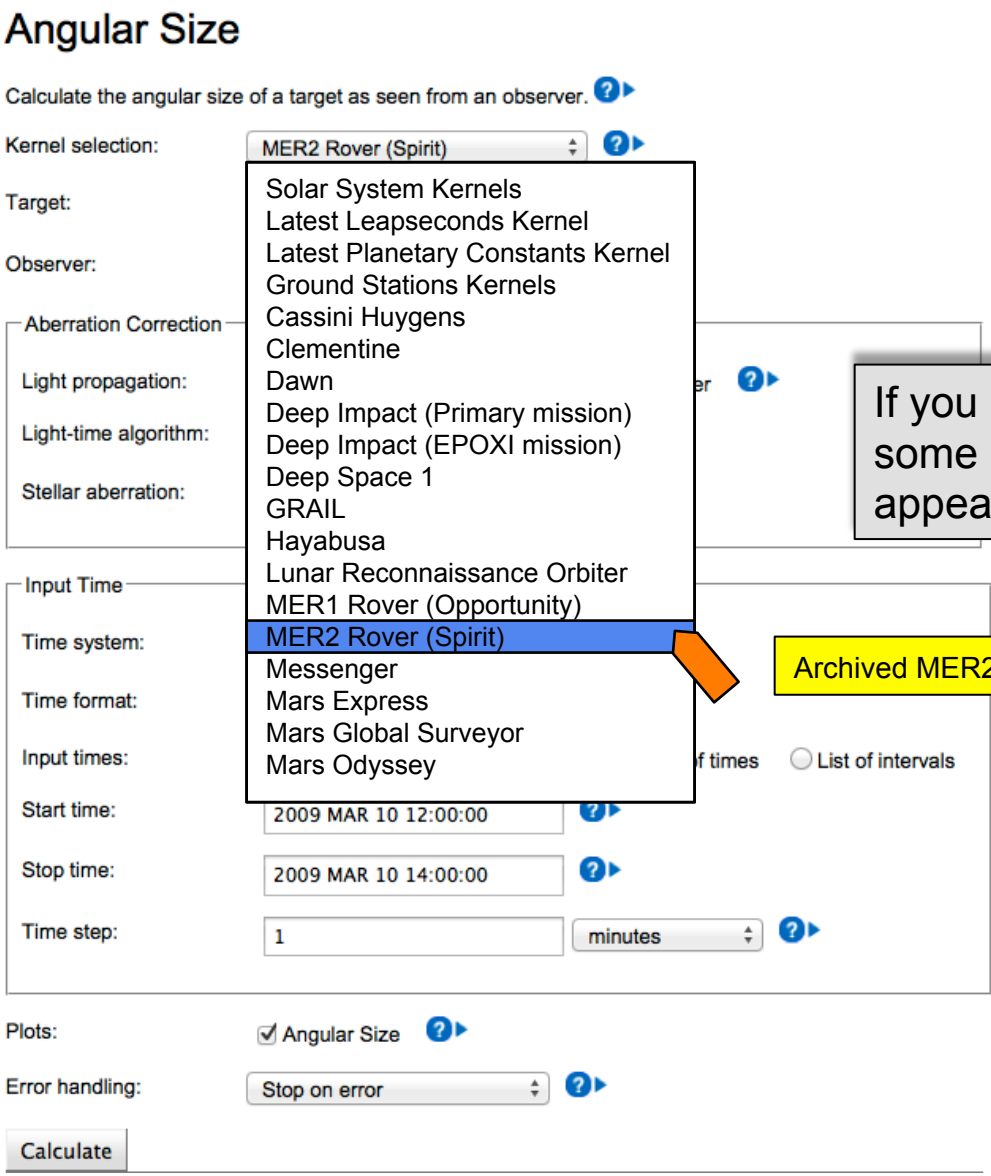
A scrollable drop-down menu is used to select the kernel set(s) to be used in your calculation.

Use the menu to select:

- **generic kernel sets**
- **archived mission kernel sets**
- **manual selection of individual kernels from operations collections**

“Tooltip” Feature

Navigation and Ancillary Information Facility



If you hover your cursor over a kernel set name, some information about the kernel set will appear–for example, dates covered by the data.

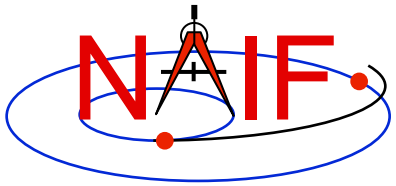
Archived MER2 kernels covering from 2003-06-10 to 2010-05-03

You can hover over the kernel set name in the “Kernel selection” menu, or in the “Kernels Selected” panel.

This feature is not available for “Manual” kernel selection.

Auto-complete Feature

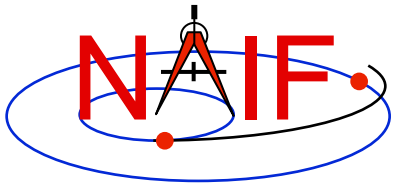
- **If you select any kernel set(s) other than "Manual", many of the input widgets will be supplied with the names of all available selections.**
  - **Just start typing the name you want and all items matching what you typed will appear in a drop down menu**
  - **Alternatively, simply type a "blank" and all items available within the kernel set(s) you selected will appear**
- **In the example below, the user has typed "mi" in the "Target" selection box. The names of the three objects matching those letters are displayed for the user's selection. (All three are satellites of Saturn.)**



Downloading Results

- **You can download tabular results to your computer by clicking the "Download Results" button, then selecting the format desired: Excel, comma separated values, or plain text**

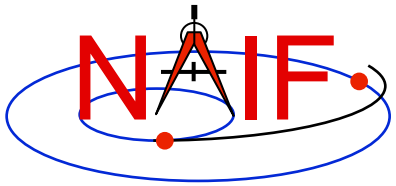
- **You can download any plots by clicking on the "Download Plot" button**
  - **Plots are saved in PNG format with a transparent background**



Saving Results for Use as New Inputs

- **You can save a numeric output, or an event finder interval start or stop time, by clicking on the value**
  - **The saved value will appear in a "Saved Values" panel on the right side of your browser window**
  - **This value can then be dragged to an input widget in a subsequent calculation**

- **You can save the complete set of event finder interval start and stop times by clicking the "Save All Intervals" button**
  - **These can then be used as part of the input for a subsequent geometric event finder computation if you select "List of intervals" for the "Input times" selection**



Limited Capability

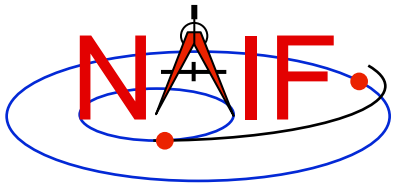
- **WGC does not provide all of the space geometry computational capability offered by the SPICE Toolkits**
  - **But WGC nevertheless provides substantial capability–likely more than is obvious at first glance**
- **More capability might be added if the user community finds this tool useful**

Usage Rules

- The WGC program has a link entitled “Rules of Use”
  - Every WGC user must read and abide by these rules
  - Most particularly note that WGC is a new and still evolving tool
- Using WGC requires some knowledge of space geometry and of NASA’s SPICE system
  - NAIF website providing SPICE information:
    - » http://naif.jpl.nasa.gov
  - Casual surfers, educators and public outreach entities may find more useable space geometry information and tools elsewhere on the web

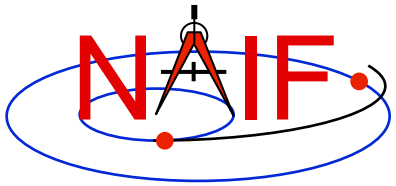
Getting Help

- WGC users must read the “About the Data” web page to understand the kinds of SPICE kernels (data) available to the WGC tool
- Most GUI controls have associated HELP text, available by clicking the  icon
- Most computation descriptions have an associated graphic depicting one or more examples of what may be computed
- Some GUI controls have a second-level, more extensive help description, available by clicking the “Read more…” text displayed in the first level help
- The NAIF Team has limited ability and authorization to provide individual help
  - Make good use of the HELP panels and other documentation included in WGC
  - Look at the SPICE tutorials and documentation available on the NAIF website
    - » http://naif.jpl.nasa.gov



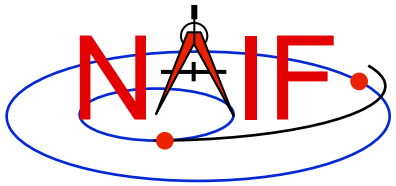
Feedback

- **WGC includes a "Feedback" button, making it rather easy to provide the NAIF team with any sort of useful feedback…**
  - **What you like or don't like about WGC**
  - **What seems incorrect, incomplete or unclear**
  - **What features you would like to see added**
    - » **Caution: NAIF already has a long list of improvements we'd like to make, so we make no promises to act on any specific feedback.**



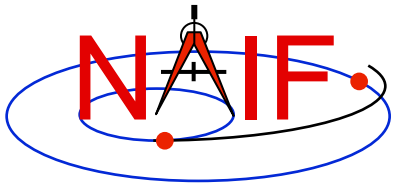
The WGC URL

http://wgc.jpl.nasa.gov:8080/webgeocalc



Problems Using WGC

- **There are several limitations and errors you might encounter in using WebGeocalc**
  - **See the next several pages for examples**
  - **Some of these conditions could be unique to the WGC installation at NAIF**

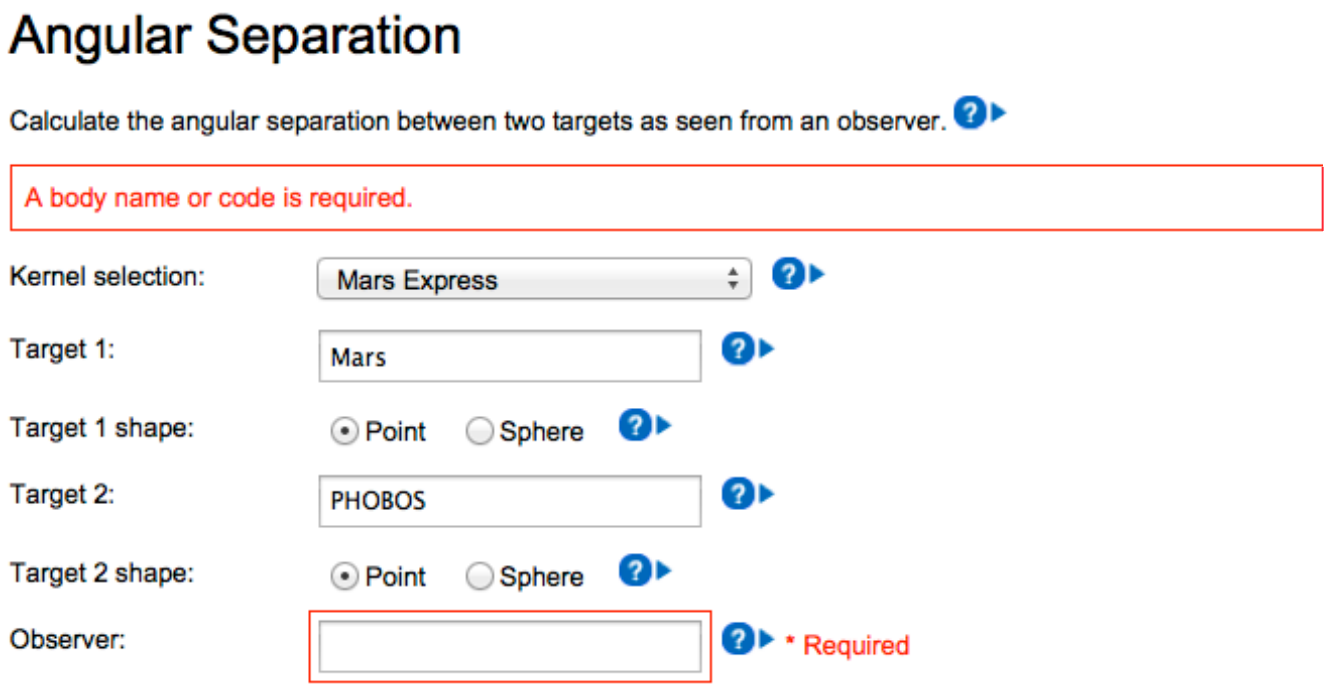


Limitation – One at a Time

- **WebGeocalc executes only one computation at a time**
  - **Any computation requests received while one computation is in progress will be queued in the order received**
    - » **A "queued" message will be displayed in your browser's window**
    - » **Each request will automatically execute once having reached the top of the queue**

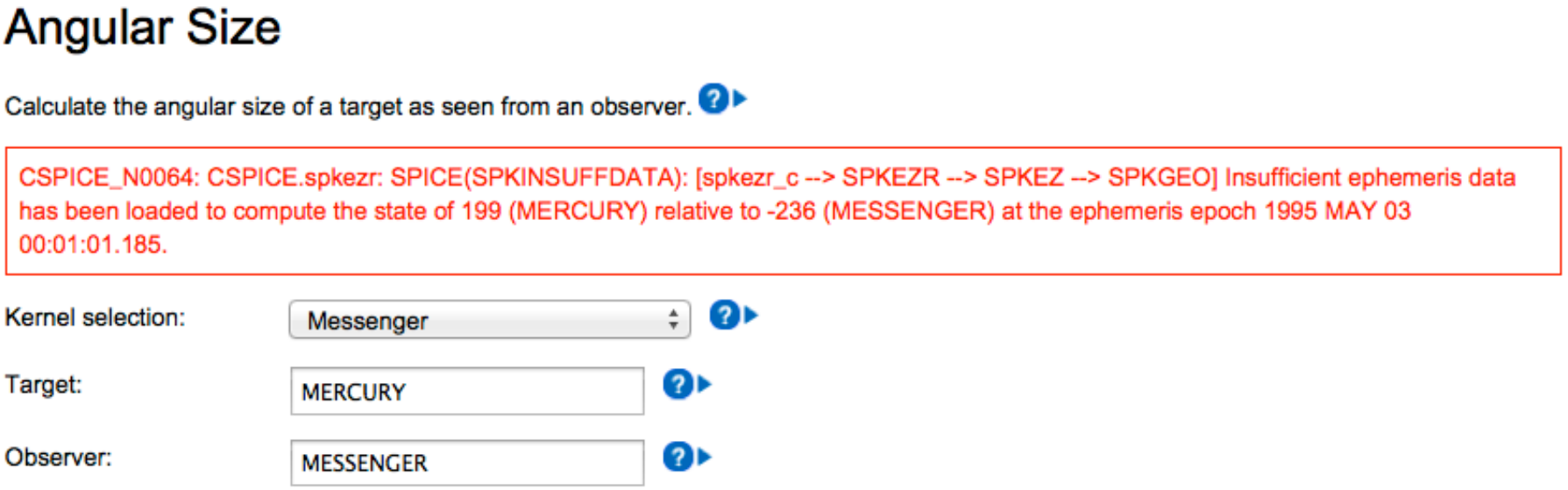
Error – Missing Input

- **WGC will alert you to missing inputs**

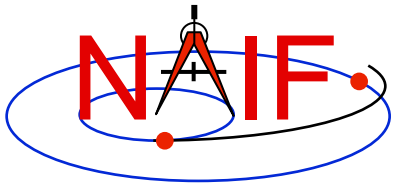


Error – Input out of Bounds

- **WGC will display a SPICE error message when SPICE is able to detect a problem.**

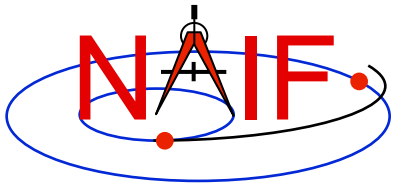


- **In this example the user requested the position of Mercury relative to the MESSENGER spacecraft at a time before MESSENGER was launched.**



Error – Missing Data

- If you try to make a series of calculations (e.g. over a time interval, or at each of a set of times) it could be that some of the calculations can be made while others can not due to data gaps or otherwise missing data
- You can control the action taken by WGC using the "Error handling" control found at the bottom of each "Geometry Calculator" web page
- The options are:
  - Stop on error (the default setting)
  - Report errors and continue
  - Silently omit errors



Error – Incomplete Data

- **For some kernel sets, one kind of data–typically a predicted spacecraft ephemeris kernel (SPK)–extends well out into the future, while other kernels–typically spacecraft attitude kernels (CK)–end at the date the mission ended**
  - **In this kind of situation, WGC can successfully execute some kinds of computations, but not others, when your computation request time extends into the "predict" region**
  - **Carefully read the kernel set coverage notes provided in the "tooltip" described earlier in this tutorial to understand data coverage for the kernel set(s) you have selected**

Limitation – Too Many Kernels

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- A few archival data sets contain a very large number of kernels–an amount exceeding a limit set within the underlying SPICE software
- If you select one of these large data sets, and then request computations over a long time range, you could see an error message like this:

```
CSPICE_N0064: CSPICE.furnsh: SPICE(FTFULL): [furnsh_c --> FURNSH --> ZZLDKER --> CKLPF --> DAFOPR --> ZZDDHOPN] The file table is full, with
1000 entries. As a result, the file '/ftp/pub/naif/pds/data/mro-m-spice-6-v1.0/mrosp_1000/data/ck/mro_hga_psp_110110_110122p.bc' could not be loaded.
```

- In this example of using the Mars Reconnaissance Orbiter SPICE archive, a time interval of four years was specified for a computation. The number of binary kernels needed to satisfy this request exceeded the limit of 1000 binary kernels allowed to be loaded at one time.

Limitation – Request is Too Large

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- **WGC has limits set on computational resources**
  - **No more than 25,000 "Geometry Calculator" computations**
  - **No more than 1 million "Geometric Event Finder" time steps**
  - **No more than 3 minutes of wall clock time**
- **If any of these limits will be (or have been) exceeded, you'll see a message saying so and your computation request will be terminated**
- **Some examples:**

Too many data points. This version of WebGeocalc can only calculate 25000 data points in a single calculation, and the requested time inputs specify 631152010 data points. Either use a smaller time range or a larger time step. NAIF plans to remove this restriction in a future version of WebGeocalc.

Time step is too small. This version of WebGeocalc requires the time step to be at least 1.0E-6 times the size of the time window. The requested time step is only 9.506426208650559E-8 times the size of the window. Either specify a smaller time range or a larger time step.